ACQUISITION SCHEME AND RECEIVER FOR AN ASYNCHRONOUS DS-CDMA CELLULAR COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to a Direct Sequence-Code Division Multiple Access (DS-CDMA) acquisition scheme and a receiver for it.

BACKGROUND OF THE INVENTION

With the development of mobile land communications, the CDMA cellular system gains importance through its use of direct sequence (DS) spread spectrum (SS), which greatly increases channel capacity. But the interference common in CDMA systems decreases their frequency efficiency with respect to other multiple access systems like Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). Nevertheless, in the cellular method, CDMA can utilize its characteristics of high efficiency for cell-repeat and durability against interference because the frequency reuse efficiency in space (cell repeating ratio of a frequency) contributes to the overall frequency use efficiency.

In the usual cellular system, two cell searches are necessary: for acquiring a cell connected to a mobile station (hereinafter an initial cell search) and for searching for a peripheral cell on handovers (hereinafter a peripheral cell search). Especially in the DS-CDMA cellular system, since each cell uses an identical frequency, it is necessary to acquire a timing error within a half-chip cycle, which is between the spread code of a received signal and the spread code replica generated in the receiver.

DS-CDMA cellular systems are classified into a synchronous system for strict time acquisition and an asynchronous system without it. The synchronous system realizes acquisition using another system such as the global positioning system (GPS). As an identical long code gives each station a different delay, the initial cell search can be executed only by performing timing acquisition of the long code. The peripheral cell search on handovers can be carried out more rapidly because the peripheral station code delay information is sent from the base station to which the mobile station belongs.

In the asynchronous system, however, each base station has a different and distinct spread code, and the mobile station needs to designate that code in the initial cell search. In the peripheral cell search on handovers, the number of spread codes for designation can be limited by obtaining the spread code information used in the base station to which it belongs and its peripheral base stations. In both cases, the search time exceeds that of the synchronous system above, and when a long code is used as the spread code, this search time is huge. However, the merit of the asynchronous system is that it requires no other system such as GPS.

A cell search is proposed so as to solve the problem of the asynchronous system and performs rapid acquisition in "Two-Stage Rapid Long code Acquisition Scheme in DS-CDMA Asynchronous Cellular System", TECHNICAL REPORT OF IEICE, CS-96-19, RCS96-12 (1996-05). The proposed acquisition scheme detects a long code timing by despreading the short code common to each cell using a matched filter first, and each cell's own long code is designated by a matched filter or a sliding correlator.

The proposed acquisition is described hereinafter. FIG. **8** shows the cell structure. As shown, each cell has a base station like BS**1**, BS**2**, . . . BSN, each of which transmits information to and receives it from mobile station **100** by doubly despread symbols using long codes #1 to #N and channel-distinguishing short codes #0 to #M. Short codes #0 to #M are common to every cell, and short code #0 is adopted to the control channel of each cell.

FIG. **9** shows the two-stage rapid acquisition above. FIG. **9** (**1**) shows examples of signals received by the mobile station. They are the received signals of control channels transmitted from base stations BS_i, BS_{i+1}, BS_{i+2}. As shown, each control channel has a symbol (the part with diagonal lines) which is spread only by short code #0, the control channel common to each base station, by one long code cycle. This is realized by not performing long code despreading in the predetermined cycle. Other symbol locations are double despread by long code #i which is different from that of each base station and short code #0 above. Such double despreading makes it possible to demodulate the control code even when mobile stations synchronously receive the timing of long codes between cells. The control channels transmitted from each base station BS_i to BS_{i+2} are asynchronously multiplied and received by the mobile station.

In a mobile station, the cell search is carried out with the two-stage structure described here. FIG. **9** (**2**) shows the first-stage performance: in a mobile station, the correlation between the received signal and the control channel short code replica "short code #0" is detected by a matched filter. As stated, each control channel has a symbol (with diagonal lines) spread in a long code cycle by short code #0 which is common to each base station. Therefore, when the correlation is detected during a single code cycle using the short code symbol replica, the correlation peaks are detected at the locations corresponding to the spread symbol receiving timings of short code #0. At the mobile station, (1) the timing detected at the largest correlation peak is recognized as the control channel long code synchronous timing of the base station which requests connection, then, (2) the long code which is spreading the control channel that detected the long code synchronous timing is designated using a single sliding correlator in order to distinguish the station. To execute it, at the initial cell search, a) long code #i is sequentially selected among the group of long codes #1 to #N decided in the system, b) the replica symbol of the selected long code #i+short code #0 is generated, and c) the correlation of synchronous timing obtained in (1) is detected. To execute the peripheral cell search on handovers, a) the replica symbol of the selected long code #i+short code #0 is generated in the group of long codes of peripheral cells informed from the base station presently connected, similar to the above, and b) the correlation is detected with respect to the synchronous timing. The correlation is thus detected by changing long code #i until the correlation detecting value exceeds the threshold value, then long code #k exceeding the threshold value is judged as the long code of the receiving control channel: this is the completion of the cell search. The base station can then be designated.

The cell search can be rapidly performed by dividing the long code timing synchronization and long code designation. In the normal asynchronous cellular system, (number of spread codes×number of spread code phases) times correlation detection is needed; on the other hand, in the proposed scheme, the correlation detection is approximately only (number of spread codes+number of spread code phases) times.

SUMMARY OF THE INVENTION

Though the cell search can be executed at high speed by this two-stage rapid acquisition scheme, the demand is for even more rapid acquisition.